THE MODEL ENGINEER

Vol. 99 No. 2479 THURSDAY NOV 25 1948 9d.

The MODEL ENGINEER

PERCIVAL MARSHALL & CO. LTD., 23, GREAT QUEEN ST., LONDON, W.C.2

25TH NOVEMBER 1948 VOL. 99. NO. 2479

SMOKE RINGS

Our Cover Picture

● IT IS very seldom that a portable engine is to be found at work, in these days. Yet our cover picture, for which we are indebted to Mr. J. Brice, of Witney, was taken only a few weeks ago, and shows a portable engine engaged in threshing the 1948 harvest on an Oxfordshire farm. The belt on the flywheel can just be seen, while the movement of the spokes is clearly depicted. It would seem that the reading of the pressure-gauge is causing some little anxiety to the old man; or, perhaps, he is thinking that these old engines are far better than "they new-fangled petrol contraptions"!—J.N.M.

Readers' Photographs

● BOOKS HAVE been published on the subject of photographing models, and a great deal of detailed information is available for those who wish to improve their technique. However, in view of the large number of photographs reaching us every day which are unsuitable for publication, a few words on general principles may be of assistance to readers in producing acceptable pictures.

(1) If you are photographing a model locomotive, let the picture be of the locomotive rather than the driver and passengers. Readers' interest is primarily in the model itself, and pictures of the other sort have already been published in their thousands. This same principle applies generally when photographing any model, the exception being when an action picture is required, such as a machining operation or the operator using his model in some unusual or specially interesting manner.

(2) Always ensure a plain contrasting background, particularly when a model is of intricate external construction and outline. When locomotives and other models have been photographed against a background of foliage, it is often impossible to distinguish parts of the model from parts of the background.

(3) If you are submitting a picture for the cover, bear in mind the shape of the cover and arrange the shape of your picture to suit.

Finally, I would say when photographing for publication, try to imagine your own reaction as a reader to the picture which you have submitted, remembering that readers are always looking for something new, something different, and always a picture in which details can be clearly seen.

Articles on photographing models were published in THE MODEL ENGINEER as follows:—

Vol. 80, June 22nd, 1939, pages 730-733. "Model Photography." How to Ensure Good Pictures. By Denis M. Neale.

Vol. 83, December 19th, 1942, page 496. "Photographing Models." Queries and Answers.

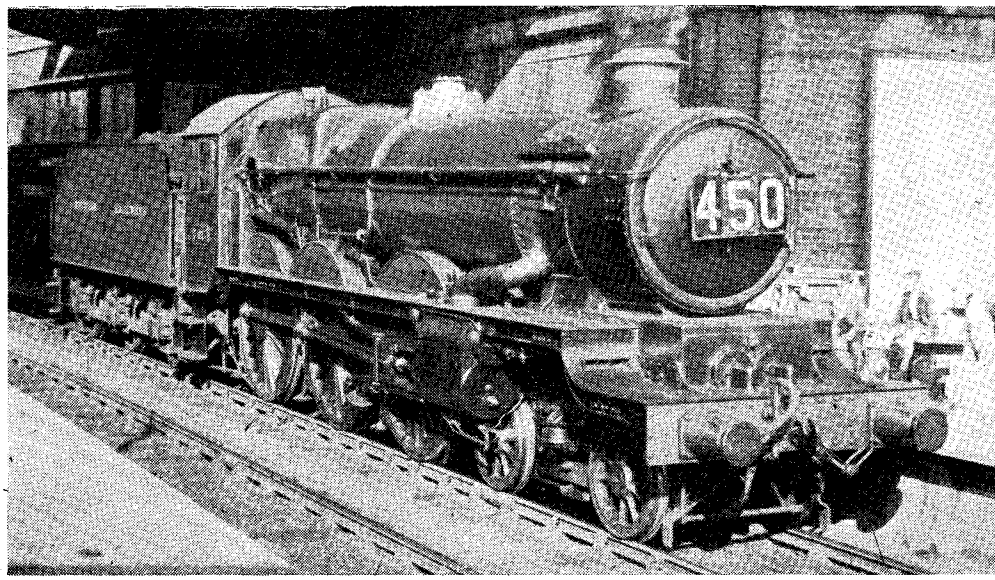
Vol. 90, May 25th, 1944, page 482. "Photography of Model Boats." By A. Galeota.

Vol. 96, January 9th, 1947, pages 37-38. "Smoke Rings." Photographing Models.

Reference to these articles may make just that difference between acceptance for publication and rejection.—P.D.

" G. J. Churchward "

● MY RECENT note about Engine No. 7017 of British Railways Western Region had not been published twenty-four hours before the whole matter was explained. On October 19th, the engine was taken to Paddington to be officially named by Captain (E.) William Gregson, R.N.R., President of the Institution of Mechanical Engineers. To my great regret, illness prevented my attending the brief ceremony; but I hope before long to obtain a photograph of the engine *with* the name. I have already published the news that I had seen the engine, on September 14th, *with* the name, and again, on October 9th, but *without* a name. On this second occasion, I took a photograph which is reproduced herewith; in it, the brackets for the nameplates are clearly visible, and I wondered if the plates had been removed for alteration, perhaps into *George Jackson Churchward*! I did not quite like that idea, and I am glad it has not been put into effect. As it is, the engine is once more simply *G. J. Churchward*, which strikes me as being more in keeping with the forthright, straightforward character of one of the greatest geniuses in the history of locomotive development.—J.N.M.



The " M.E." Speed Boat Competition

● MODEL POWER boat enthusiasts are reminded that entries for this year's competition are accepted up to December 31st, and that any runs during the season are eligible for entry, provided that the necessary evidence regarding timekeepers and witnesses are available. The evidence of any figures recorded in the reports of M.P.B.A. regattas will be accepted. The awards include silver and bronze medals in Classes A, B and C for boats propelled either by steam or petrol engines, both the engines and hulls of which are built by the competitor.

The number of entries in this competition have been very poor in recent years, and not at all representative of the very large number of readers who build and run model speed boats. I take this opportunity of hoping that all those who have taken part in competitions during the season will send in their entries and enable me to give a truly representative report on model speed boat activities during the year. Entry forms can be obtained, post free, from this office.

—E.T.W.

Utilising " Surplus " Apparatus

● ONE OF our readers, who wishes to remain anonymous, has offered to put up a prize of £2 2s. od. for the best idea in the utilisation of war surplus apparatus, of the type which figures largely in the advertisement columns of many technical journals at present, and has also been dealt with in articles in THE MODEL ENGINEER by " Artificer " and other contributors. Many valuable practical suggestions have already been made in these articles, but it is more than probable that many readers will have further original ideas on the subject. We, therefore, invite contributions dealing with any useful and ingenious device, either mechanical or electrical which has actually been successfully constructed, wholly or mainly from material obtained from surplus apparatus. The articles should be illustrated by photographs and/or drawings, and the origin, and as far as possible, the type or classification of the material specified.

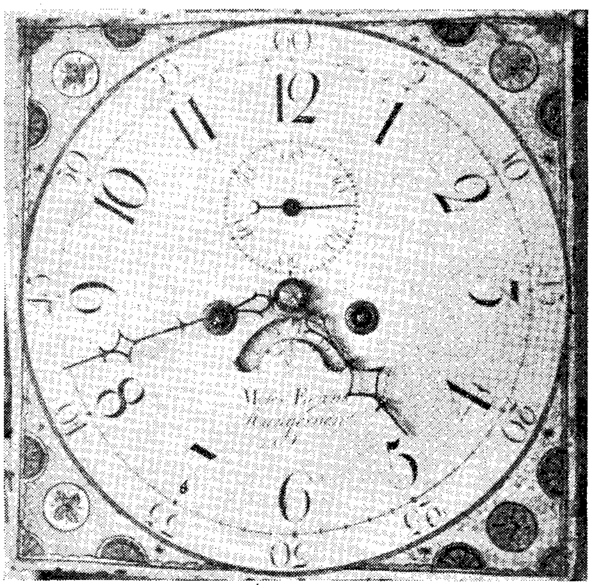
In addition to the prize for £2 2s. od., the best contribution will be paid for at our usual rates; so, too, will any other articles submitted which are considered worthy of publication. Entries should be addressed to the Editor and marked " Surplus Competition." The closing date will be January 17th, 1949.—E.T.W.

" Rejuvenating Grandpa "

by " Artificer "

Some Practical Notes on the Repair and Restoration of Old Clocks

THE model engineer is often called upon to apply his skill and workshop equipment to jobs in the sphere of domestic engineering, in order to keep the peace and justify his indulgence in a hobby which, to the lay mind, is often regarded as a mild form of lunacy. Anyone who is known to be " handy with tools " is in great demand, not only in his own home, but also among the circle of friends, neighbours and casual acquaintances, to undertake jobs which are rarely profitable, sometimes tedious and difficult—and usually impossible to dodge, even with the aid of the most subtle and fluent diplomacy. Mr. Jones's lawnmower, Mrs. Brown's sewing machine, and even Mrs. Smith's perambulator, are all brought to the model engineer's workshop for treatment—" it won't take you a minute to fix it, old chap ! " But this naive estimate generally proves wildly optimistic, and results in the time schedule for the completion of that " Royal Scot," racing hydroplane, or other *magnum opus* being sadly disorganised. Such is life !

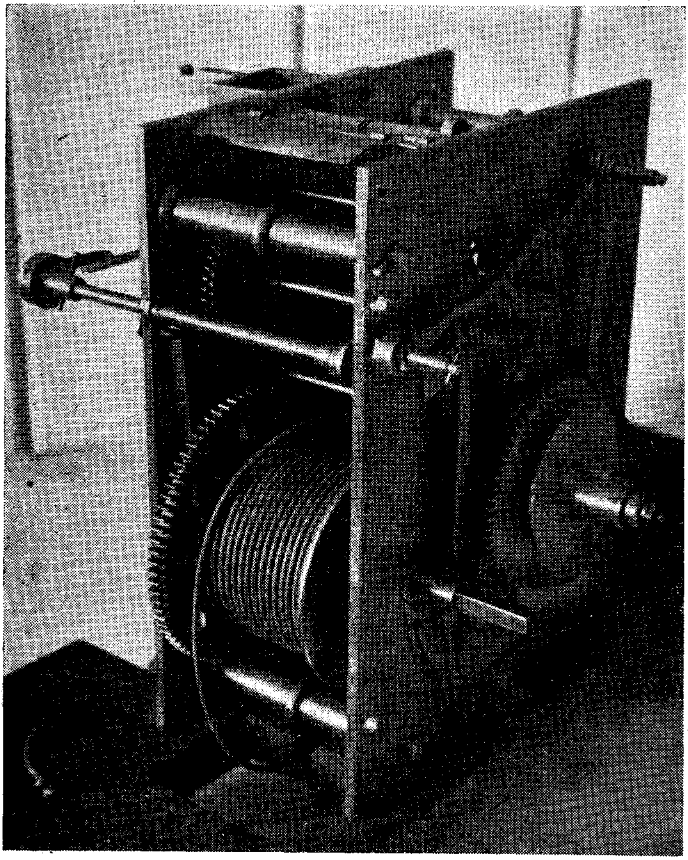


Dial of typical English eight-day long-case clock, with seconds and calendar dials

Among the many *hors d'oeuvres* of this nature on which the ministrations of the model engineer are solicited, most common is the repair of clocks and watches, a class of work which is nowadays more in demand than ever because of the scarcity of these products, and the fact that most professional repairers are up to their eyes in work. Let it be said at once that watch repairing is a highly specialised job, which calls not only for an uncommon degree of skill in the handling of minute parts, but also tools and equipment suited to this work. But the repair of clocks—or at least the larger and more substantial types—is well within the scope of both the tools and skill of the average model engineer, and moreover, it is extremely interesting work, and excellent training in precision fitting and mechanical manipulation. The latter is perhaps the most important from our particular point of view, for it constitutes the only valid incentive, or indeed excuse, for encroaching on a class of work which might be regarded as the special preserve of the professional horologist. Let it be clearly understood that the object of this article is not to turn the model engineer into a blackleg rival or cut-throat competitor of this worthy tradesman ; as a matter of fact, many of the jobs which the former would be keen to undertake for interest's sake would be regarded by the latter as impracticable purely on economic grounds.

One may fairly safely assert that most of the jobs brought to the notice of either the amateur or professional repairer are not worth spending time and trouble on—a statement which I think will be endorsed by most people in the clock trade. The cheap modern clocks, and for that matter, many of the older clocks, were never designed or built to stand repair, and painstaking work in the replacement of worn or damaged parts is inconsistent with the flimsy and slapdash technique of their production. Nevertheless, the cheap clocks at least have the virtue of providing scope for self-training in work of this nature, and should not be despised by those who wish to learn. It has been said that a man who can make a really satisfactory repair of a cheap German alarm clock could mend anything—even to a broken heart, which he may easily acquire in the attempt !

With the really well-made old clocks, such as an early English bracket or long-case clock, however, things are very different. These clocks



Clock movement, showing striking barrel and train

were made of substantial, durable materials, by methods truly akin to those of the model engineer, not to mention equipment of a comparable though more primitive nature. Moreover, they fully justify the time spent in repair work, for they are excellent timekeepers, and a clock which has given good service for 150 years or more may often be renovated to be capable of at least an equal further span of life. The old English "Grandfather" clock, of the type brought to its acme of perfection by Thomas Tompion, was perhaps the finest domestic clock ever made, and though the products of the most reputable makers have been plagiarised by those of lesser ability, generally with inferior results, it may be said that most of the clocks built on this general pattern have at least been fairly satisfactory.

Quite a large number of these old clocks are in existence at the present time, but only too often they are found to be out of working order through some major or minor derangement—but nearly always something which could be put right by a competent worker. The writer has repaired many clocks of this type, to the great delight of their owners, who had been authoritatively informed that they were "completely worn out." In most cases the trouble consisted of such things as worn arbors and bearings, escapements badly adjusted or out of beat, or faulty winding clicks and ratchets. Only very occasionally was it found necessary to renew completely a spur wheel or pinion, though in clocks driven by chains (mostly Continental makes) the primitive sprocket gears are often partially or completely stripped. One cannot help admiring, and in fact marvelling at, the workmanship in these old clocks, carried out with primitive tools and very "raw" materials—food for thought and encouragement when we model engineers are confronted with problems which call for similar resourcefulness.

The writer claims no special skill or experience in horology, but only a keen interest which has prompted him to undertake the restoration of these clocks, and the following hints are offered for the benefit of readers who may have a similar interest—or who may be coaxed, cajoled or coerced into doing such work by their relations or acquaintances. One of my friends has told me how he was forced, willy-nilly, into becoming an amateur clock repairer. Being in the R.A.F. and therefore expected to know "all about machinery," he was once, in a weak moment persuaded to undertake the examination of a clock that wouldn't go. Partly through his own lack of knowledge, and partly through the assistance of a member of the family who unscrewed the clock plates while the going and striking springs were fully wound up, a minor "explosion" resulted—and the remaining hours of the night were spent in retrieving the parts from all corners of the room, and assembling the "jigsaw puzzle" which they presented. No joke by any means at the time—but it was the beginning of a lasting respect and interest in clocks which has often proved extremely useful since.

Cleaning

Readers may have noticed that whenever a watch is taken to the local watchmaker for some trivial repair job, the oracle of the ocular will say, after a careful squint at the interior, "Badly in need of cleaning, isn't it?" This fact may not be so obvious to the owner, but it is quite true that watches, and to a somewhat lesser degree clocks as well, are very much affected by dirt in the working parts; and moreover, a correct diagnosis of any mechanical trouble is often

impossible until all the parts are properly cleaned. Old clocks are often in a shocking state inside, and the very first job on any clock is the removal of the accumulation of dirt, fluff, congealed oil and often rust which has collected through ages of inattention. This process normally entails the complete dismantling of the "works," and it is most important, at this stage of the proceedings, to make certain that the position of every part is known and memorised—or if memory is likely to fail, identification by some method of marking is advisable. In these old clocks, largely made by hand, interchangeability was unknown, and in many cases, even the few screws employed in their construction will only fit their individual holes. Most of the parts, including the main plates or frames, dial plates, etc., are secured by taper pins, cotters or stakes, and these also will generally be found to vary in size.

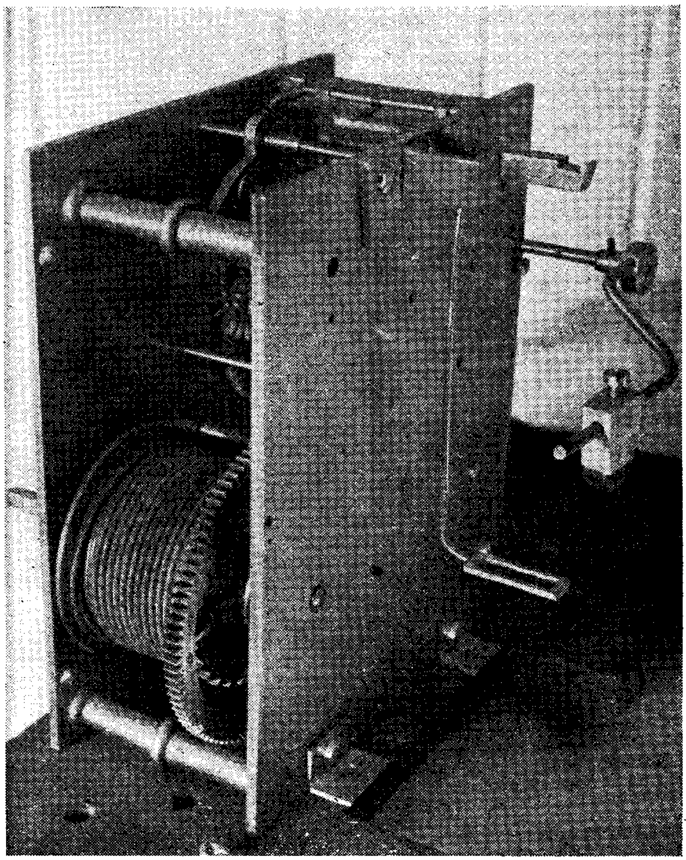
Cleaning is largely a matter of elbow grease, assisted by such solvents or cleaning fluids as are available. For restoring the pristine brightness of the brass parts, Mr. George Gentry some years ago advocated the application of lemon juice, which is really a mild version of the acid dip treatment, and if any form of acid is brought into contact with iron or steel parts, rapid and complete removal (or neutralisation by alkaline counteraction) is necessary to avoid corrosion or pitting. Generally speaking, however, it is safest to avoid chemical methods of cleaning, and rely on rubbing down with old and well-oiled emery-cloth, followed by rottenstone or pumice. Arbors and similar steel parts may be polished with fine emery-cloth in the lathe, but if the wheels are treated in the same way, the cloth should be glued to a "buff stick" so that it does not catch in the teeth or spokes, and produce that rounding off of the corners which is so slovenly and unsightly.

Some painstaking workers may aim at a very high finish of the parts, with a high polish or "snailing" of the plates, but this is, of course, a secondary matter compared with the mechanical work, and may prove to occupy more time than is really justified. Many old clocks were made from plates cast, rolled or beaten by primitive methods, and not at all highly finished; while further marring of the surface caused by subsequent work in the bushing of arbor bearings—or merely burring them over—is very common.

After cleaning the plates, all traces of abrasive matter must be scrupulously removed, for obvious reasons, and the normal lodging place for such matter—the bearing holes—is the one place from which its eviction is most essential. In watchmaking practice, the final cleaning of these holes is done by "pegging" by tapered splints of soft wood, the process being carried on until a new peg is found to come out clean; and one cannot do better than emulate this method, using pegs of appropriate size. It is possible that some readers who wish to do a quick job may try to follow the methods often used for cleaning watches nowadays, without taking them to pieces, by using baths or sprays of solvent fluids; but while it is not impossible to clean most of the superficial grime away in this manner, it is not recommended to the conscientious worker.

But the crudest methods sometimes work, after a fashion, as shown by the story of an ancient clock which had done service for untold generations in an old farmhouse. On several occasions this faithful servitor had shown symptoms of slight indisposition, and when this

(*Continued on page* 555)



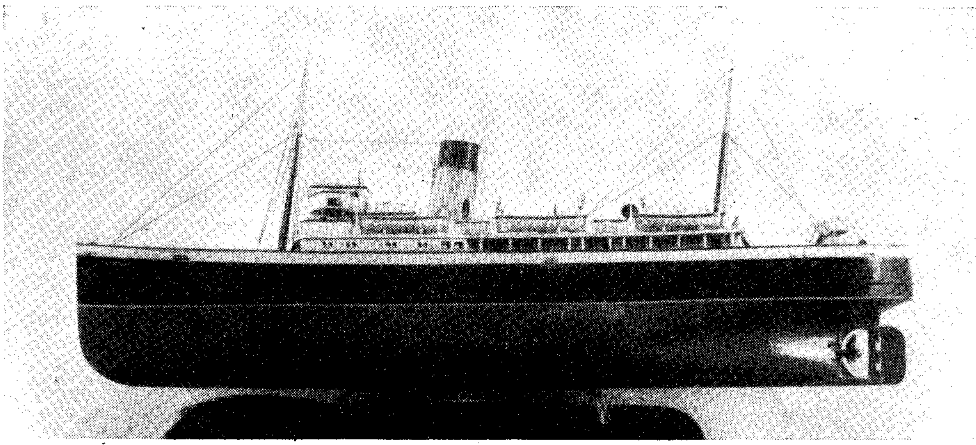
Another view of clock movement, showing going barrel, pallets and crutch

*A Model Cross-Channel Steamer

The "BRITTANY"

by J. E. Jane

I THINK I must have made up a dozen or so before I produced companion ways to my satisfaction. I cut off each step from a piece of tin, which had already been marked out. Each one was $\frac{3}{8}$ in. long, and 3/32 in. wide, and I had to produce something like 50. Looking around for material for the sides, I discovered a few lengths of thin brass strip $\frac{1}{8}$ in. wide. These were cut to the required lengths, and together with the "steps," were well tinned. Both items were now set into the jig, as shown in the drawing, clamped together, and "sweated in" with a hot iron. (Fig. 5 and 5A.)



Mr. J. E. Jane's finished model

Davits (Fig. 6 and 7)

These were made up from $\frac{1}{16}$-in. diameter brass wire. The shaping was done with the aid of a jig.

Blocks and Pulleys (Fig. 8)

These were fashioned from a couple of bone knitting needles. As each block was only $\frac{1}{8}$ in. by about 3/32 in., it was something of a job to produce 24. (I can appreciate our galleon makers with their "hundreds.") Each length of needle was first filed until I had two flats, then the dimensions of each block were marked out. With a small bradawl I located the position for the holes, which were next drilled with a 1/32-in. drill. Each block was then cut out; the groove to hold the strop was cut out with the aid of a small "knife-blade file." The strops, hooks and "eyes" were made up from fine fuse-wire.

Funnel (Fig. 9)

This was "rolled" from a flat piece of tin, the edges butt-soldered together. The banding was carried out with 1/32-in. diameter copper wire The siren, and exhaust pipes are dummies. The former was made up from a length of 3/32-in. brass wire, and a piece of $\frac{1}{8}$-in. diameter brass filed to represent the "whistle" part. The latter were constructed from 3/32-in. o.d. copper tube.

Ventilators (Fig. 10)

These are made from brass tubing, and sheet brass. To form the cowls, I had to make up some formers, rounded off to the requisite size. A grindstone helped me in this matter. Several annealings were necessary before sufficient depth was obtained. The cowls, having been formed, were cleaned up, and soldered on to their respective tubing. The edges of the cowls were then ringed with 1/32-in. copper wire.

Companion-way Hoods (Fig. 11)

These were made from a couple of pieces of boxwood, hollowed out with a small gouge made up for the job.

Skylights (Fig. 12, 13 and 14)

These were "fabricated" from thin sheet tin. The method of shaping up can be ascertained from the drawing.

---

*Continued from page 537, "M.E.," November 18, 1948.

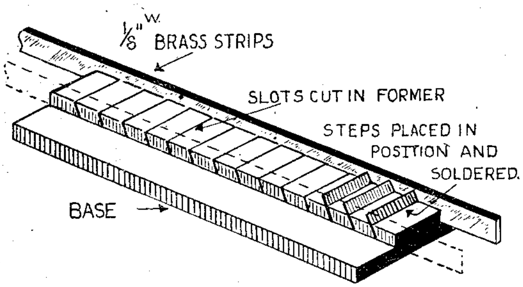


Fig. 5. Wooden jig for making ladders

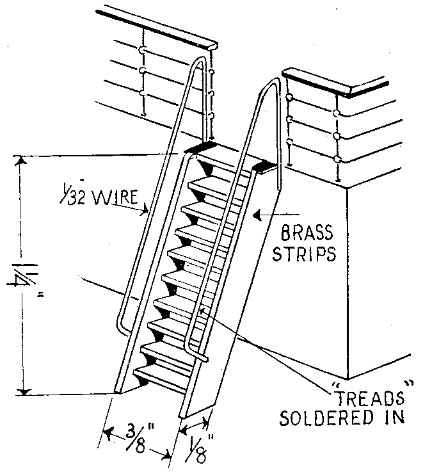


Fig. 5A. Companion ladders

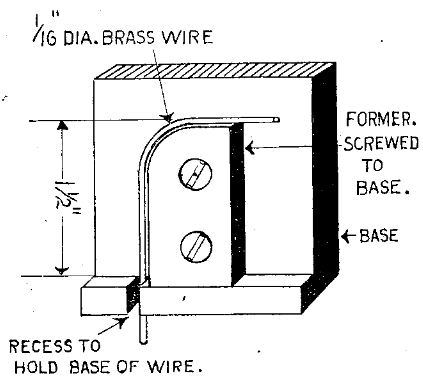


Fig. 6. Jig for forming boat davits

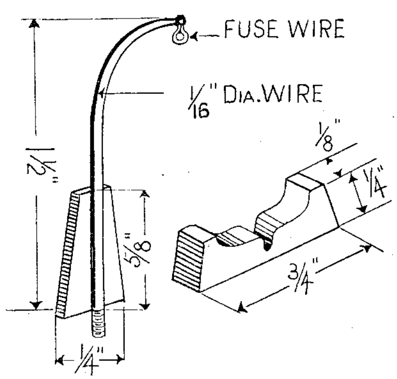


Fig. 7. Boat davits and "chocks"

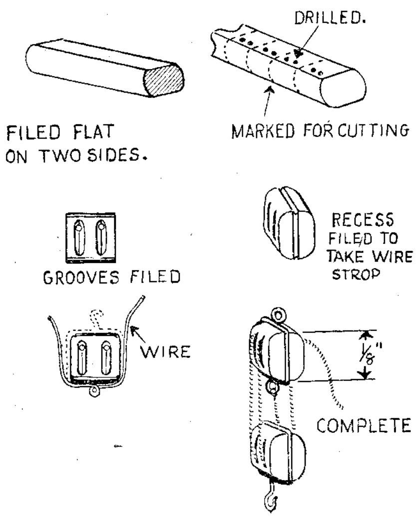


Fig. 8. Lifeboat blocks

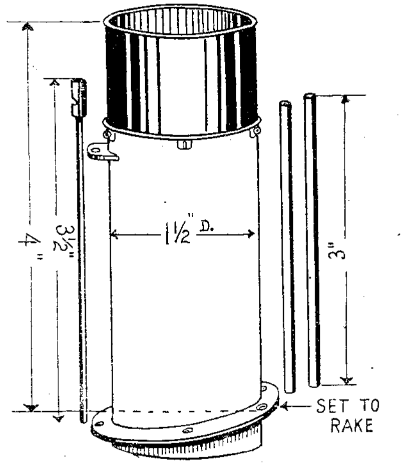


Fig. 9. Funnel, with components

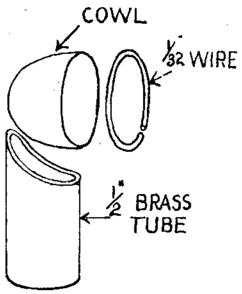


Fig. 10. *Ventilators*

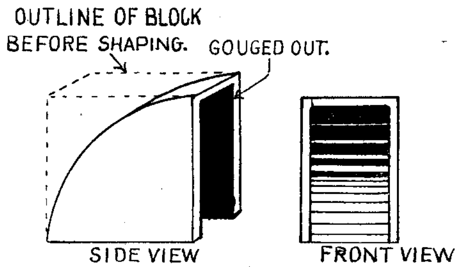


Fig. 11. *Companion-way hoods*

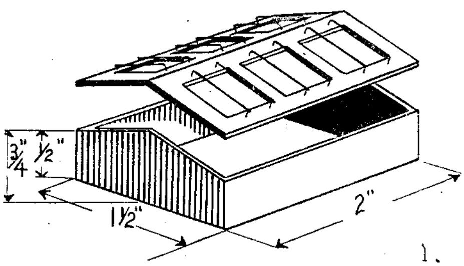


Fig. 12. *Engine-room skylight*

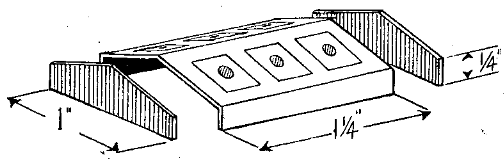


Fig. 13. *Boiler-room skylight*

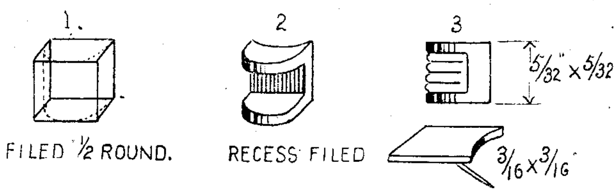


Fig. 15. *Masthead, lamps and platforms*

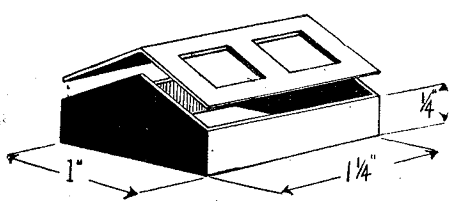
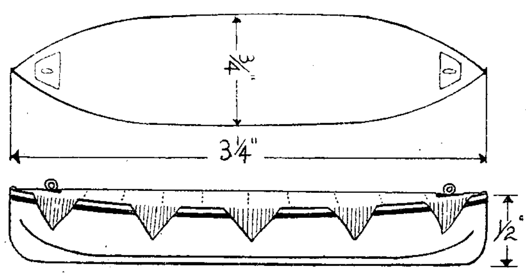
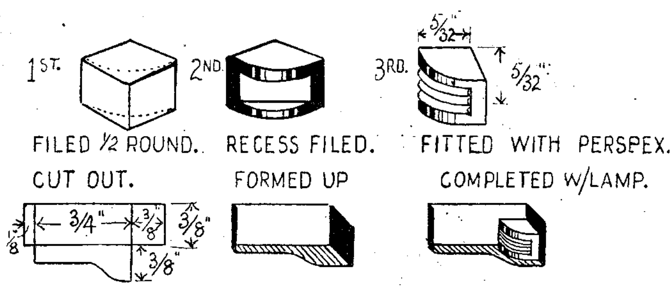


Fig. 14. *Deck cabin skylight*



Above—Fig. 17. *Lifeboats*



Left—Fig. 16. *Navigation lamps with shields*

Masts and Fittings

(Refer to Fig. 2 [Mast].) These were fashioned from $\frac{3}{16}$-in. diameter dowels of white pine, tapered with a file and a small concave scraper, which I "knocked up" especially for the job. Grooves were cut to take the mast bands, which were formed from fuse-wire. The masts trucks were fashioned from a couple of ordinary pins. The main mast bands, to which the shrouds are fastened, were made from small brass washers and the sockets, from a couple of 0.22 cartridge cases.

Masthead Lamps and Navigation Lights (Fig. 15 and 16)

In the former case, pieces of 3/32-in. sq. copper were used. In the latter case, the lamps were filed up from $\frac{1}{4}$-in. sq. brass. Perspex was used for glass.

Rigging

Shoemakers' thread and fishing line were used for this item, being well waxed before assembly. The amount of rigging on the model is only about one third of that on the prototype. For one thing, I could not pick out with any accuracy the complete rigging from the photograph; and for another, I have already had trouble over broken lines at the pond side. So in view of the small scale, and the amount of handling the boat would receive, I cut my rigging down to the minimum.

Lifeboats (Fig. 17)

Each boat was carved out from a piece of yellow pine, from a set of cardboard templates. Five are covered with linen to represent the covers, and the last one is left uncovered. This has been fitted out with seats and a set of oars, which were carved from pieces of $\frac{1}{8}$-in. diameter beech dowelling.

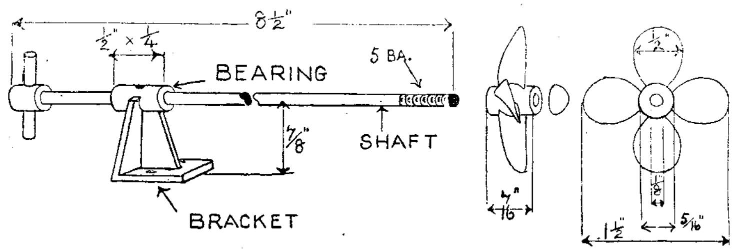


Fig. 18. *Propeller and shafting*

Propeller (Fig. 18)

Four bladed, medium pitch, $1\frac{1}{2}$ in. diameter. This is fabricated, and is made from brass. Each blade was cut separately, and sweated into the boss. This was made from a brass collar $\frac{1}{4}$ in. diameter, and is drilled and tapped 5 B.A. to screw on to the shaft, where it is held in position with a lock-nut. Actually, I made up two propellers before satisfaction was reached. The first one seemed to be of too coarse a pitch as it tended to stop the engine. So far, the second "prop" has functioned admirably. In altering the design, the only modification was a little more taper at the tip of the blades, plus an extra twist, until each blade was almost cutting the water, edge on, the angle at the base being about 40 deg.

(*To be continued*)

"Rejuvenating Grandpa"

(*Continued from page* 551)

occurred, the farmer, who by his own admission was "no mechanic," would get the works out of the case, and with the oilcan from the threshing outfit, apply liberal doses of oil to all the accessible bearings. For a time, the robust constitution of the clock survived this treatment; but eventually there came a day when it ceased to have the desired effect, and so the farmer packed up the works and directed his wife to take them to the local clockmaker for repair. So appalling was the state of the working parts, however, that the clockmaker, after one look at them, exclaimed in horror "Take it away—and boil it!" These instructions were taken quite literally by the good wife, whose instincts of domestic economy led her to make use of the suds left in the copper after washing day; and the detergent effects of soap and soda effectively cleaned the clock, which took on a new lease of life. But the painted dial—which had not been removed from the clock—was completely destroyed, and had to be replaced by a paper one. So if you ever visit a farmhouse in the heart of the West Country, and see a fine old grandfather clock with an obviously amateur-made paper face—you will know that this story is true!

Needless to say, this story is not intended to point a moral—unless it is, "if you must boil a clock, take the dial off first." As most of the clocks within the scope of this discussion will require a certain amount of mechanical attention, dismantling of the working parts, with careful cleaning and examination, will in any case be an essential preliminary operation.

(*To be continued*)

Rocket Propulsion

by D. Hurden

DESPITE the fact that solid fuel rockets are said to have been used in warfare by the Chinese before the invention of the cannon, it was the bombardment of London by V2's that brought home the fact that the rocket can be much more than a harmless toy. The giant V2, considered to be one of the major technical achievements of the war, was the accumulation of over twenty years' experience with rockets large and small. Let us see what the construction of a rocket involves and how amateurs have helped to solve some of the problems in the development of this type of power unit.

A rocket, like an aircraft turbo-jet, is a jet-propulsion device which derives its thrust from a stream of gases ejected behind it. The essential difference between them is the fact that a rocket carries with it all the oxygen it needs to burn its fuel, whereas a turbo-jet uses oxygen from the surrounding air, from which it follows that a rocket will work just as efficiently outside the Earth's atmosphere. Its oxygen can be mixed with the fuel in some form or else carried as a separate material. For convenience, the fuel and oxidiser are termed propellants.

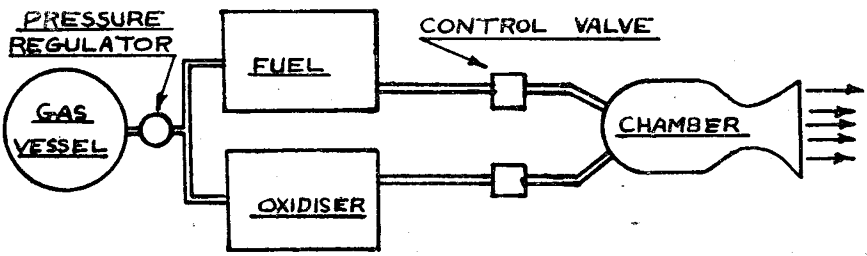


Fig. 1

Method of Operation

When a suitable mixture of the propellants is introduced into a combustion-chamber and ignited, rapid combustion takes place, generating a pressure inside the chamber. The gaseous products of combustion escape from a nozzle at the rear and form a high-speed jet. The combustion-chamber is, therefore, a means of accelerating a mass of gas backwards, so, by Newton's well-known Third Law of Motion, the rocket is accelerated forwards. It can be shown that the efficiency of the rocket depends on the velocity of the jet, and, as in steam turbine nozzles, the jet velocity can be increased by allowing the gases to expand in a gradually diverging nozzle; therefore most rocket combustion-chambers are provided with a divergent exhaust nozzle.

For various reasons, liquid propellant rockets are preferred for aircraft and guided missile propulsion. The complete rocket motor can be divided into three parts: the propellant feed system, the control system, and the combustion system, which we will consider briefly in turn.

Two main forms of feed system are used. In one the propellant tanks are pressurised by some inert gas, and on opening the control valves the gas pressure forces the propellants into the combustion chamber. A diagram of such a system is given in Fig. 1. In cases where the rocket has to run for more than, say, half a minute, the second system is generally used. In this case the propellants are fed by pumps driven by some form of prime mover. A diagram of the V2 feed system is given in Fig. 2. On this rocket the pumps were driven by a turbine running on steam produced by the chemical decomposition of hydrogen peroxide.

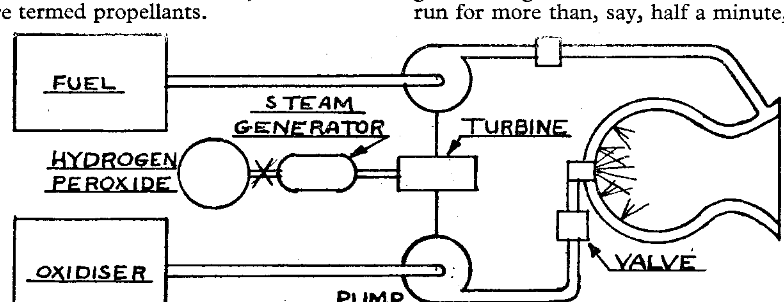
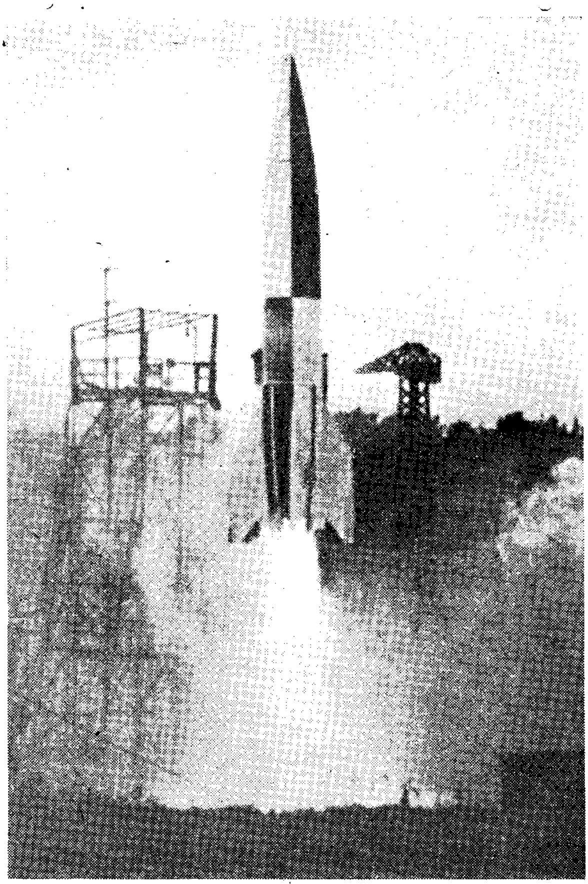


Fig. 2



Launching a V2 rocket

The design of a control system for a rocket calls for much ingenuity. The system has to be very positive in action, since a slight delay in the opening of one valve may produce an accumulation of one fuel in the chamber which will cause an explosion on starting, so stop-valves operated by compressed air are generally used. If desired, a variable thrust can be obtained by using a manually-operated throttle valve to control the propellant flow directly or to vary the speed of the unit driving the pumps.

Injectors

The combustion-chamber is fitted with an injector, which may take many forms, the object of all of them being to break up the propellant into a fine spray suitable for burning. This spray can be ignited in several ways. Some pairs of propellants ignite spontaneously on mixing, others require a separate igniter, which may take the form of an electrically-fired cartridge, a small " pilot " chamber ignited by a sparking plug, or even a firework. The combustion-chamber itself has to stand high pressures and temperatures of the order of 2,000 to 3,000 deg. C. For short duration runs it may be lined with a refractory material such as carbon or ceramic. Motors running for a minute or more are usually cooled by surrounding the chamber with a jacket through which one propellant circulates before entering the chamber. This is known as regenerative cooling and is now used on all large rockets.

Propellants

Choice of rocket fuel offers great scope, for, in addition to many solid fuels, there is an enormous choice of liquid propellants. Some fuels, called monergols, containing their own oxygen supply, have only to be ignited to burn, and, of course, simplify the feed system considerably, since only half the number of pumps and valves are needed.

A second class, called hypergols, contains fuels which burn on mixing with their oxidant. A typical hypergolic propellant is hydrazine hydrate as fuel and hydrogen peroxide as oxygen carrier. The third main class of propellants, non-hypergols, which do not ignite on mixing, includes such fuels as petrol, kerosene, and alcohol used with an oxidant such as liquid oxygen or hydrogen peroxide.

Full-size Rocket Motors

Although the principle of the rocket has been known for very many years, liquid-fuel rockets date only from the 1920's, when a few pioneers in America and Germany began to experiment with them. In Germany, especially, the work grew in importance, and during the last war two liquid fuel rockets were used operationally on a comparatively large scale. The smaller of these formed the sole power plant of the Me.163 interceptor fighter. This motor used a hypergolic propellant system, the fuel being a mixture of hydrazine hydrate, methyl alcohol and water, and the oxidant being hydrogen peroxide. It developed a thrust which was variable up to a maximum of 3,500 lb. and weighed only 390 lb.

The Guided Missile, V2

The second rocket used operationally was the giant 50-ft. guided missile, V2, a photograph of which appears above. This is the largest rocket so far constructed. The propellants were alcohol and liquid oxygen, and it developed a thrust of about 60,000 lb., the combustion-chamber being cooled regeneratively by the alcohol. The motor ran for about a minute and the missile then continued on its way for about 150 miles, reaching a height of over 40 miles and a speed of 3,000 m.p.h.

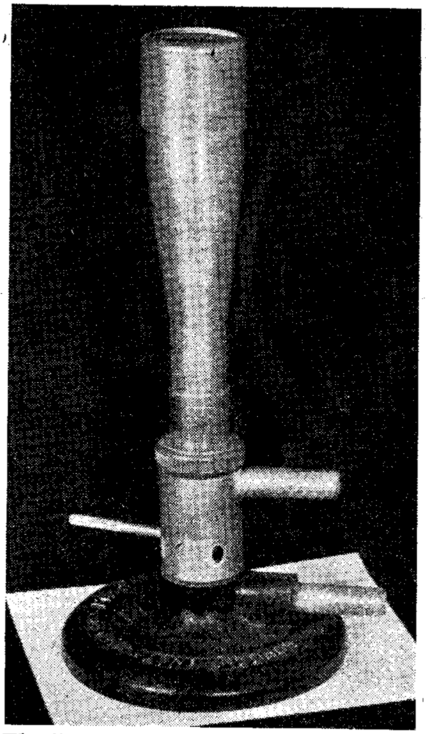
(*To be continued*)

A Forced Draught Bunsen Burner

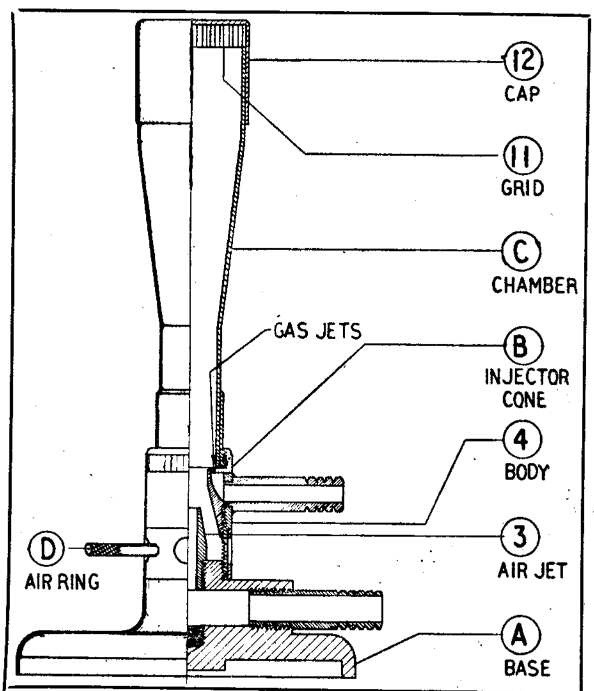
THE utility of the simple bunsen burner for heating purposes in the workshop or laboratory is well known to all engineers, and wherever gas supply is available, it is generally regarded as an essential item of equipment.

The efficiency of this type of burner can be considerably augmented by increasing the supply of air to the mixing tube by means of forced draught, but this demands some elaboration of the design of the burner to ensure proper combustion and avoid either lying back into the mixing tube or blowing out.

A burner designed for use with forced draught has recently been produced by the Gordon Instrument Co. Ltd., Clinton Place, William Street, Sheffield, who have submitted a sample for our inspection. The general form of the burner is somewhat similar to that of the ordinary laboratory bunsen burner, but in addition to the usual air regulator for natural draught at the base of the mixing tube, it has a supplementary air inlet for connection to a forced draught fan or blower which injects extra air into the centre of the tube. The gas is supplied to an annular passage above the air jet, where it emerges into the tube through a number of holes equally spaced around the periphery. The mixing tube increases in diameter at the upper end and is fitted with a ferrule enclosing a grid of refractory metal, which acts both to improve the mixing of the air and gas, and also prevents blow-back down the tube.



The "Gordon" forced draught bunsen burner



Part sectional drawing of burner, showing internal gas and air passages

This type of burner, when supplied with a moderate pressure of air from bellows or rotary blower, produces an extremely intense and large volume flame which is suitable for hardening and tempering tools, or the heating of crucibles or cupels. It is not suitable for use in an enclosed furnace.

High-intensity gas burners have been in great demand for use in chemical and metallurgical laboratories, but up to the time of the war, the only ones available were of Continental manufacture, and the supply has not since been resumed.

A $3\frac{1}{2}$-in. Gauge L.M.S. Class 5 Loco.

by "L.B.S.C."

HERE, as promised, are some illustrations and details of a suitable boiler for young "Doris." Whilst following the outline of the boiler on the full-sized engine, I have introduced two or three variations, to make the construction easier. Big sister's boiler has a parallel front section, and a steeply-tapered second ring going up to the throatplate level; but I have made the actual boiler taper gradually right from the smokebox, like the full-sized engine's lagging. Secondly, although the top of the Belpaire firebox-wrapper has the conventional back slope, the sides are parallel instead of tapering in. This makes it easier both for wrapper and inner firebox construction, and only those deliberately seeking something to moan about, would notice it. The firebox tubeplate is vertical, and the front section of the foundation-ring is dispensed with; another "easier-to-make" innovation. The inside of the boiler is arranged according to my usual "tried, tested, and proved" specifications, so nobody need be afraid of being short of steam, as long as they keep using the shovel at the right time and in the right manner.

As I have only just finished detailing out the flanging, riveting, brazing, assembling, and other operations used in making a little locomotive boiler, in connection with those for "Maid of Kent" and "Minx," there is no need to repeat the ritual so soon afterwards. All the operations are carried out in exactly the same way; so if I go through the general construction, and note the differences in the shape of the plates, crown-stays, throatplate joints, sloping backhead and so on, nobody should have the least difficulty in building a boiler that will "do the doings."

Barrel and Wrapper

The barrel may be made either from tube or sheet. If the former, a piece of $4\frac{1}{2}$-in. diameter 13-gauge seamless copper tube will be needed, a little over $10\frac{1}{2}$ in. long. Cut a V-piece out of it, a full $1\frac{1}{2}$ in. wide at the end, tapering down to nothing; close up the V, and rivet a butt-strip of 16-gauge copper inside, extending almost full length, but leaving $\frac{1}{4}$ in. at the wide end, and $\frac{3}{8}$ in. at the narrow end, so that the smokebox tubeplate and the stepped joint-ring may be inserted. If the rivets are spaced about an inch apart, it will be quite all right, as this seam is brazed along with the throatplate joint. It is also an advantage to bevel the edges of the cut a little, so that when the job is riveted up, the edges form a V, in which the brazing material can run easily. Carefully file off both ends so that they are square with the bottom of the barrel, where the joint is. Beginners note, when the boiler is assembled, the bottom is parallel; only the top slopes.

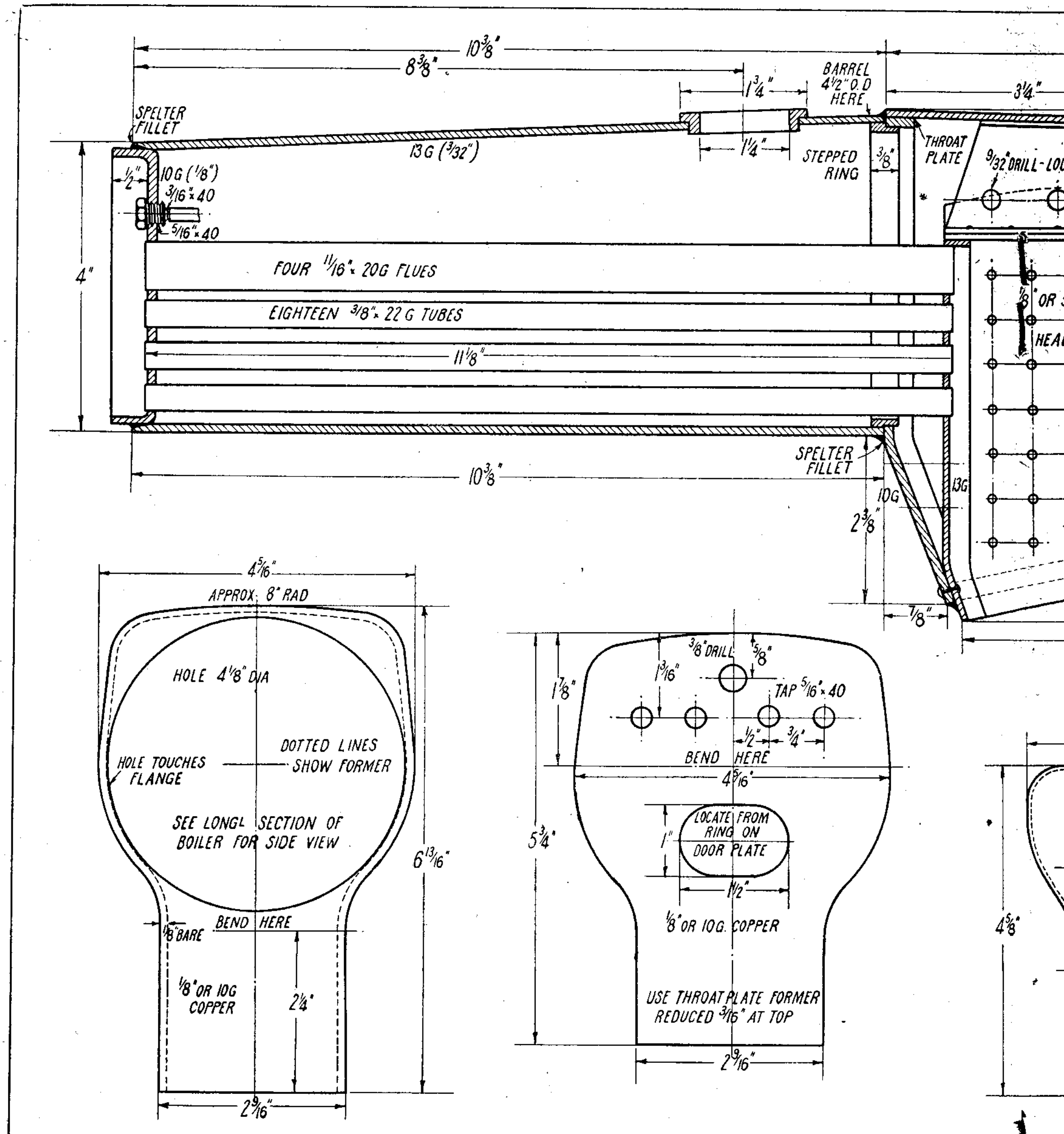
The barrel can also be made from a piece of 13-gauge sheet copper rolled up to a taper, and lapped over approximately $\frac{3}{8}$ in. Rivet the lap seam with 3/32-in. copper rivets at about 1-in. centres, and serve the ends as described above. The diameter outside the small end should be 4 in., and the larger end $4\frac{1}{2}$ in.

The throatplate is flanged up from $\frac{1}{8}$-in. or 10-gauge sheet copper, over an iron former, the shape and dimensions being shown in the composite illustration. Make it the same as a flat backhead for the kick-off; then, when you have flanged it, and filed off any raggedness, saw two nicks out of the flanges at the place where the bends have to come, and bend to the angle shown in the illustration. Then cut a circular hole in the upper part, as big as possible, touching the flanges at top and sides. Clean up the flanges with a file, and clean all around the hole.

It is quite possible that our advertisers may be able to supply a casting in good gunmetal, or even copper, for the stepped ring. Although I wouldn't use cast plates in a boiler under any circumstances, there is no harm in using the cast ring, as the strength of the boiler at this point doesn't depend on the casting, but on the brazed or Sifbronzed joint. The ring is merely to keep the barrel and throatplate lined up correctly, whilst the brazing is under way. Personally, I don't use a ring at all. I just stand the firebox wrapper, with throatplate attached, end-up in my brazing-pan; set the barrel on it in the right position, letting it stand by just its own weight alone, and then get busy with my "Alda" blowpipe and Sifbronze welding-rod. If a casting isn't available, bend a piece of $\frac{3}{8}$-in. by $\frac{1}{8}$-in. copper strip into a circle that will just fit the larger end of the barrel; silver-solder or braze the joint, then chuck it on the outside step of the three-jaw, and carefully turn down half of it to a push fit in the hole in the throatplate.

The firebox wrapper is bent up from a piece of 3/32-in. sheet copper a full 8 in. wide. The exact length can be obtained by running a piece of soft copper wire, or thick lead fuse-wire, around the throatplate flange, and then straightening it out. If you allow for the $\frac{3}{16}$-in. backslope, and the difference in depth between the front and back of the firebox, it is a kiddy's exercise in mental arithmetic to reckon up the length of the back end; but it can be got from the backhead itself, if you like to make that component at this stage. Saw $\frac{3}{16}$ in. off the end of the throatplate former, round the corners, and flange a bit of $\frac{1}{8}$-in. or 10-gauge copper sheet over it, same as throatplate, but cut to the length shown in the illustration. To make the bend, nick the flanges with a saw, at the position indicated, and bend outward as shown. Incidentally, these nicks don't make the slightest difference to the strength of a brazed or Sifbronzed job.

The bends in the wrapper are made over a piece of bar held in the bench vice, as described for the 5-in. gauge boilers. If the copper is annealed, it will bend readily enough; I find it does, although I'm not so strong as I used to be. Clean the edges, and rivet the longer end of the wrapper to the throatplate flange with a few 3/32-in. copper rivets. Don't bother about fancy heads,

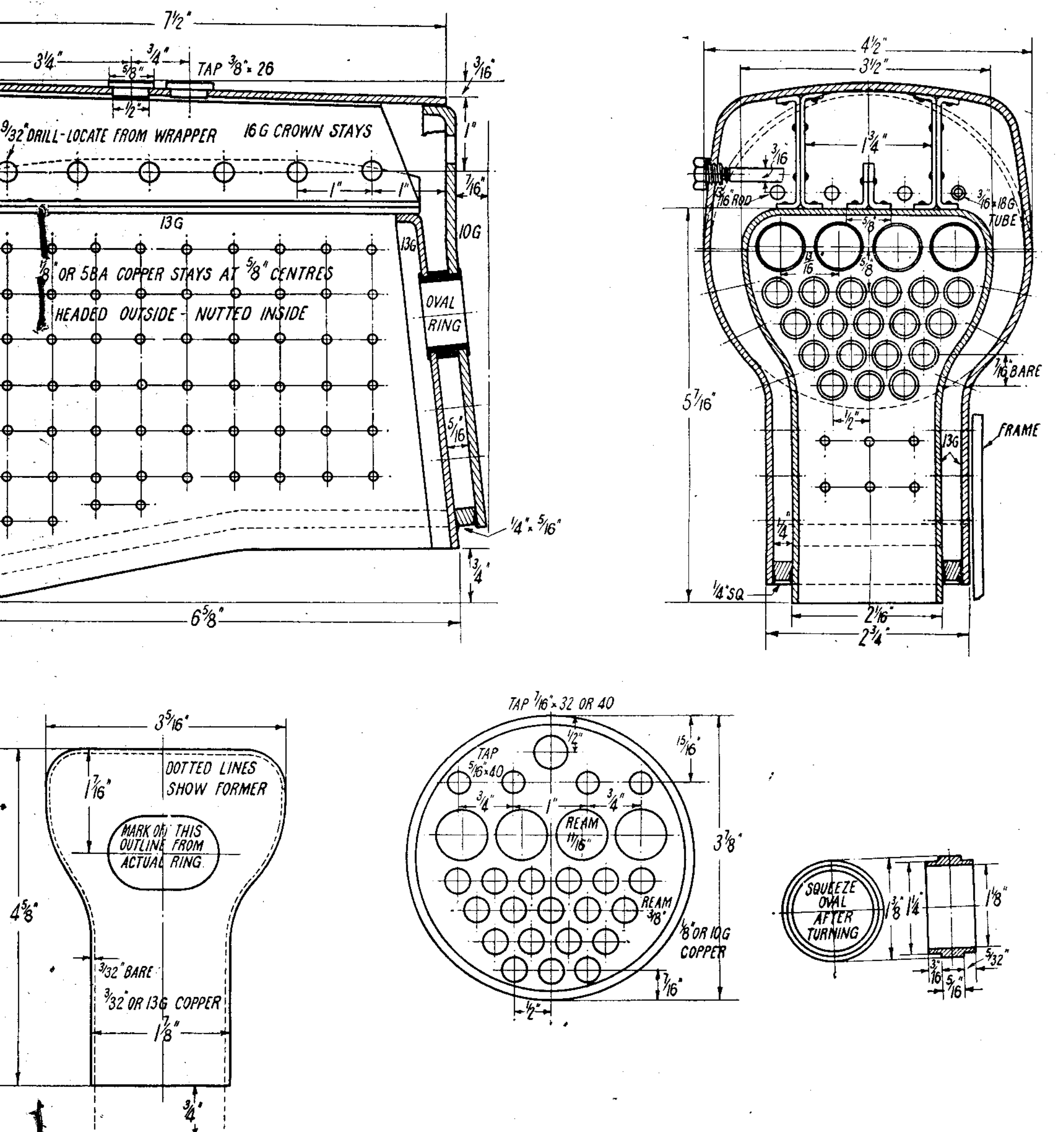


Top—Sections of boiler for " Doris " *Bottom (left to right)—Throatplate, b*

they are filed off after brazing, and only use enough to keep plate and flange in contact. The lower part of the wrapper sheet is trimmed off to match the slope of the throatplate.

Brazing up the Shell

Put the smaller step of the ring in the hole in throatplate ; smear some wet flux around it, then put the barrel on. If the end of the barrel is bevelled off a wee bit, it will help the brazing material to penetrate. Put on some more flux, also give the joint between the wrapper sheet and throatplate flange a good dose. Then up-end the shell in your brazing-pan, and go right ahead with the brazing, exactly as described for " Maid " and " Minx." Start at one bottom corner of throatplate, work your way up, and continue around under the barrel, and down the other side. Then turn the shell in the pan, so that the open side of the firebox is away from you, go all around the joint between the wrapper and throatplate flange, and finally between barrel and throatplate.



...tplate, *backhead, door plate of firebox, smokebox tubeplate and firehole-ring*

Run a really good fillet around the barrel wherever you can, such as at the upper part of the throatplate. Where the barrel and throatplate meet flush, at each side, also on top, where they are nearly flush, see that the melted brazing material runs well into the joint. Don't worry if you get a blob or two projecting beyond the barrel; it can easily be filed flush afterwards. Sound joints should be the first consideration; you can make it look pretty afterwards.

The firebox is made similar to the "Maid's" but to the given dimensions. One former does for both tubeplate and door plate. Make it to the dimensions shown by dotted lines, then set out the tube holes on it, and drill them No. 40. Round off the sharp edge one side. When the tubeplate has been flanged, as previous instructions, run the No. 40 drill through all the holes, and carry on through the copper. Remove plate, file off any raggedness, open out all the holes with a 23/64-in. drill, and ream the four lower rows $\frac{3}{8}$ in. Open out the top row further still,

with a 43/64-in. drill, and ream $\frac{11}{16}$ in. Countersink all holes slightly on the side opposite the flange; nick the flange, and bend the plate as shown.

Next, flange up the door sheet, making the top-to-bottom length as shown in the drawing, and fit the firehole ring. This is a 21/32-in. length of $1\frac{3}{8}$-in. by $\frac{1}{8}$-in. copper tube, turned down for $\frac{3}{16}$ in. length to $1\frac{1}{4}$ in. diameter at one end, and for 5/32 in. length at the other end. Anneal, and squeeze oval in bench vice. Lay the ring on the door sheet at position shown, scribe a line around, cut out the piece, insert the 5/32-in. lip of the ring, and beat outwards and down, hard on to the door plate. Don't forget that the ring projects on the side opposite the flange!

The firebox sides and crown are made from 13-gauge sheet copper, the exact size being obtained by measuring around the tubeplate and door-plate flanges, as described for the wrapper. Bend to shape over a piece of bar in the bench vice, and rivet the shaped sheet to the tubeplate and door-plate flanges by a few 3/32-in. copper rivets. Be sure the surfaces in contact are perfectly clean.

The crown-stays are of my pet girder type, the outer ones being formed of two channels riveted back to back, and the centre one by two angles, similarly attached; the bottom flanges of all the lot, are riveted to the top of the firebox at the spacing shown. All the channels and angles are bent up in the bench vice from 16-gauge copper sheet. Several of my own engines have crown-stays made from printing blocks, cheque plates, and so on; these are of excellent copper, and as Inspector Meticulous can't see through the firebox wrapper, it is O.K. to use them. Note that the side girders are $1\frac{3}{8}$ in. high at the back end, but $1\frac{5}{16}$ in. at the front, to match the sloping top of the wrapper.

The firebox joints are brazed up in precisely the same way as the wrapper and throatplate joints. Do the door plate first, and run a good fillet around the firehole ring. Then do the tubeplate, and be mighty careful not to melt the copper between the tube holes. Finally, run some silver-solder (coarse grade) along the crown-stay flanges, and see that it sweats clean through, also that it covers all the rivet heads; then run a little fillet of brazing-strip along the edge of each flange, as a sort of finishing touch. Pickle, wash off and clean up.

Tubes and Smokebox Tubeplate

There are eighteen $\frac{3}{8}$-in. by 22-gauge fire-tubes, and four $\frac{11}{16}$-in. by 20-gauge superheater flues. If your lathe has a hollow mandrel big enough to take them, square off all the ends in the lathe, to a length of $11\frac{1}{8}$ in. In passing, I might mention that this is about the limit of efficiency for a $\frac{3}{8}$-in. tube; longer tubes would need to be a little larger in diameter, to have any steam-producing effect at the smokebox end of the boiler. Clean up the ends with a bit of coarse emery-cloth; brazing material and silver-solder "take" better on a roughened surface.

We shall need the smokebox tubeplate, to act as spacer and "holder-up" when silver-soldering the tubes. This is a disc of $\frac{1}{8}$-in. sheet copper a full 5 in. diameter, flanged over a circular former $3\frac{11}{16}$ in. diameter. Countersink or bevel off the inside of the front end of the barrel, so that it tapers slightly the opposite way to the outside. After turning the raggedness formed off by the flanging, reverse the tubeplate on the chuck jaws, and turn down the outside of the flange to a very tight fit in the front end of the boiler. There should be a little V left all around the edge, for the brazing material to run into, as shown by the black marks in the sectional illustration.

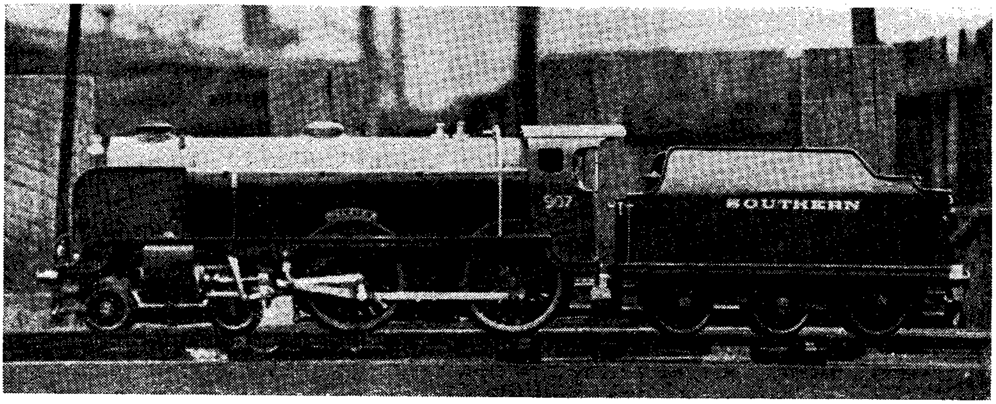
Scribe a line across the middle of the flanged plate, on the opposite side to the flange, and at $\frac{7}{16}$ in. from the edge, make a centre-pop. Put the firebox former over the plate, so that you can see the centre-pop through the middle hole in the bottom row; then adjust so that you can see the scribed line crossing the centre of the middle hole in the third row. Clamp the former to the tubeplate in this position, put the No. 40 drill through all the holes, take off the former, and open out, drill and ream the holes, same as in the firebox tubeplate, but slightly countersink *both* sides. The tapped holes for the stay nipples and the steam-pipe flange can then be set out, drilled and tapped, as shown in the illustration.

The procedure of fitting and silver-soldering the tubes, is exactly the same as detailed out for "Maid" and "Minx" boilers a few weeks ago, and so it would only be a waste of time and space to set it all out again. Suffice it to say that whilst experienced boilersmiths can put the whole lot in at one fell swoop, novices and inexperienced workers would be well advised to do this job in two or even three instalments. Far better spend a bit more time on the job, and have it perfect, than to find you have Welsh vegetables sprouting on the great day when the locomotive takes the road for the first time. As a famous radio artiste truly says, "it *can* happen—and it *does*!" Don't forget to soften the smokebox end of the tubes after finishing the silver-soldering, as per previous instructions.

First Stage of Erection

Whilst the "technique" of erecting the firebox and tubes in the shell is practically the same as described for the "Maid" and "Minx," there are two details which differ. One is, that there is no front section of foundation ring to bother about, and the firebox tubeplate being bent at the bottom to the same angle as the bottom of the throatplate, the two are riveted together direct with three or four 3/32-in. copper rivets. The second difference is that the smokebox tubeplate is inserted with the flange outwards, forming a spigot on which the smokebox is fitted. Be careful to have the crown-stay flanges in contact with the top of the Belpaire wrapper for their full length, and put a few rivets through each flange. When brazing-in the smokebox tubeplate, proceed as described for the 5-in. job, using the "holey" tray, but the brazing-strip or Sifbronze is applied outside the flange, and the V-groove completely filled up. Don't worry if it overflows; a file will put that right afterwards. The tubes are expanded and silver-soldered into the tubeplate, and the crown-stay flanges silver-soldered or brazed to the wrapper, in exactly the same way as previously described. In the issue of October

(*Continued on page* 564)



TWO "O" GAUGE LOCOMOTIVES

by A. Beale

THE "Schools" Class locomotive is based on "L.B.S.C.'s" design "The Bat" described in THE MODEL ENGINEER, during the war, but with the trimmings added.

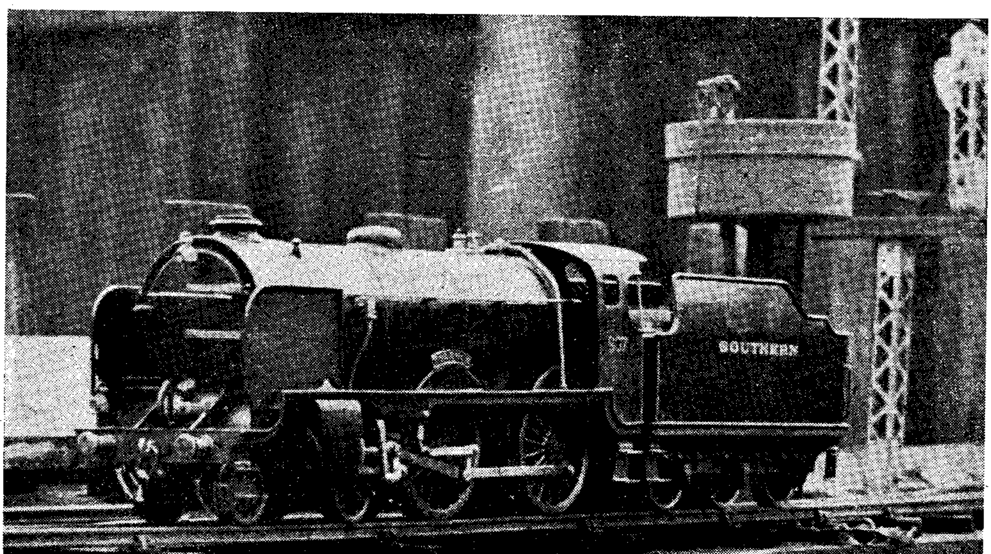
She is spirit-fired, and works at 8 lb. per sq. in. No difficulty was experienced in building the engine, castings being used for wheels, and die-castings for tender axleboxes, which were modified, for springing, by filing out the dummy boxes, and making new ones a nice sliding fit; spring buckles, and top of boxes were drilled for coil springs which greatly improved the riding of the tender.

The Walschaerts gear is dummy, slip-eccentrics taking care of the valve events.

Back-head fittings are: regulator, blower, and water-gauge, this last being rather a squeeze in the water-tube boiler, but it is quite reliable; the gauge glass was obtained from the pinch of an electric lamp.

Trouble was experienced, at first, in maintaining steam, but was eventually traced to the air tube on the chicken-feed system; the diameter of tube was increased to $\frac{3}{8}$ in. diameter, and no further trouble ensued.

The largest haul to date is four bogie coaches



The "O" gauge spirit-fired S.R. "Schools" class locomotive

and sixteen trucks, so she has plenty of power.

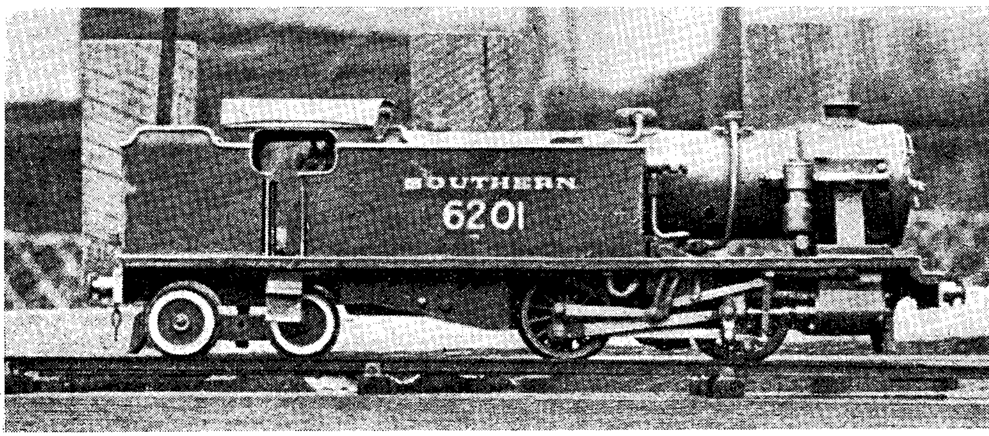
At the Chelmsford Model Engineers' Exhibition, where, much to my surprise she obtained a first prize, she was in steam on the Wednesday, Thursday and Friday nights, and all day Saturday till 8.30 p.m. The only difficulty was to stop wheel-spin on the new club track.

I am not troubled with this on my own outdoor track, a 56-ft. run, round the lawn, with one station, and passing loop.

The other locomotive is also for gauge " O " and may be of interest. It is free-lance, and makes no claim to beauty. It is coal-fired, with top-feed, and has a hand-pump in side tank as well as an axle-driven pump. The Walschaerts gear in this case does its proper job, and can be notched up, when the difference in steam consumption can be observed.

The reversing lever was a fiddling job, with working latch! Lubrication is hydrostatic; the lubricator can be seen at the side of the smokebox, an attempt being made to simulate a Westinghouse pump, she will certainly pull and go, though great care is needed when firing, " little and often " being the rule.

The photographs were taken by a friend—Mr. Attridge, under very difficult conditions, the sky being overcast at the time.



Mr. A. Beale's " O " gauge, free-lance coal-fired locomotive.—Beauty not claimed !

" L . B . S . C . "

(*Continued from page* 562)

14th last, I stated that a mate with an extra blowlamp, to play on the outside of the wrapper whilst the operator-in-chief looked after the inside, and manipulated the bits of silver-solder and brazing-strip, was desirable ; but " Doris's " boiler being much smaller, the single five-pint blowlamp should manage the job all right, though even in this case, to paraphrase an old saying, " two lamps are better than one."

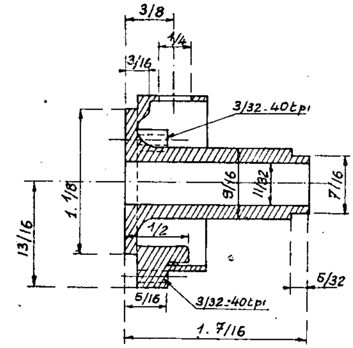
The Rest is Easy !

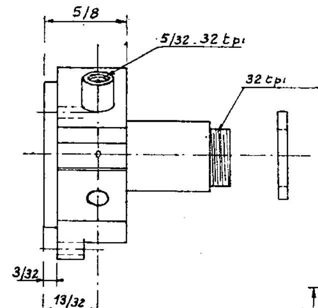
The backhead is fitted the same way as the " Maid's," and the pieces of copper rod forming the foundation-ring, set in place and riveted. Note that the water-space at the back, is $\frac{1}{16}$ in. wider than at the sides ; and don't forget to bevel off the sides of the pieces of rod, just a little, to let the brazing material flow in. There are only three bushes to fit ; the dome bush, and two for the safety-valves ; note that the latter should be set with the flange seats horizontal, so that the safety-valves will not emulate the Leaning Tower of Pisa. Finally, set about the last " hot job " as previously described for the bigger boilers. If you can get a second blowlamp on the go, do so, but the five-pint one is powerful enough to manage the job single-handed. Anybody who is scared of damaging the brazed joints already made, as more heat is needed on " the final," can use coarse-grade silver-solder instead of strip, which melts at a dull red and is just as strong but more expensive. Use best grade silver-solder, such as " Easyflo," for the flange of the firehole ring and the bushes. Once more I'll repeat, mind the splashes and the vapour when you put the boiler in the pickle. Leave it in for about 20 minutes, then drain out, well wash in running water, inside and out ; clean up, and test for " pinholes " by the method already described.

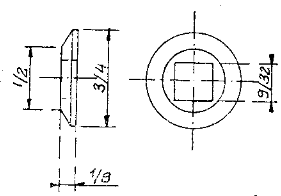
*A Racing Compression-Ignition Engine

by G. M. Suzor

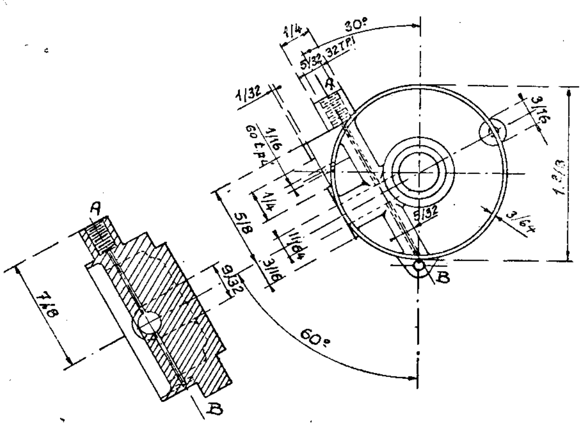
THE boring of the needle valve passage and its thread is a little difficult, but one could avoid this thread by using the frictional effect of the stuffing-box and its nut (19). I have not designed a filling cap, as this may be found on the market (usually to cover lubricating washer, but only a sufficient precision in the turning of each of these pieces. On the other hand, it is absolutely necessary to insert a paper washer between the pieces (11) and (16). The cylinder is made from hard steel (if possible hardened) and the three ports are not difficult to cut, but



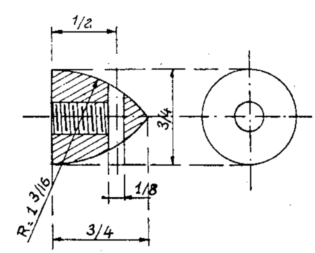




Part 14. *Light alloy*



Part 10. *Light alloy*

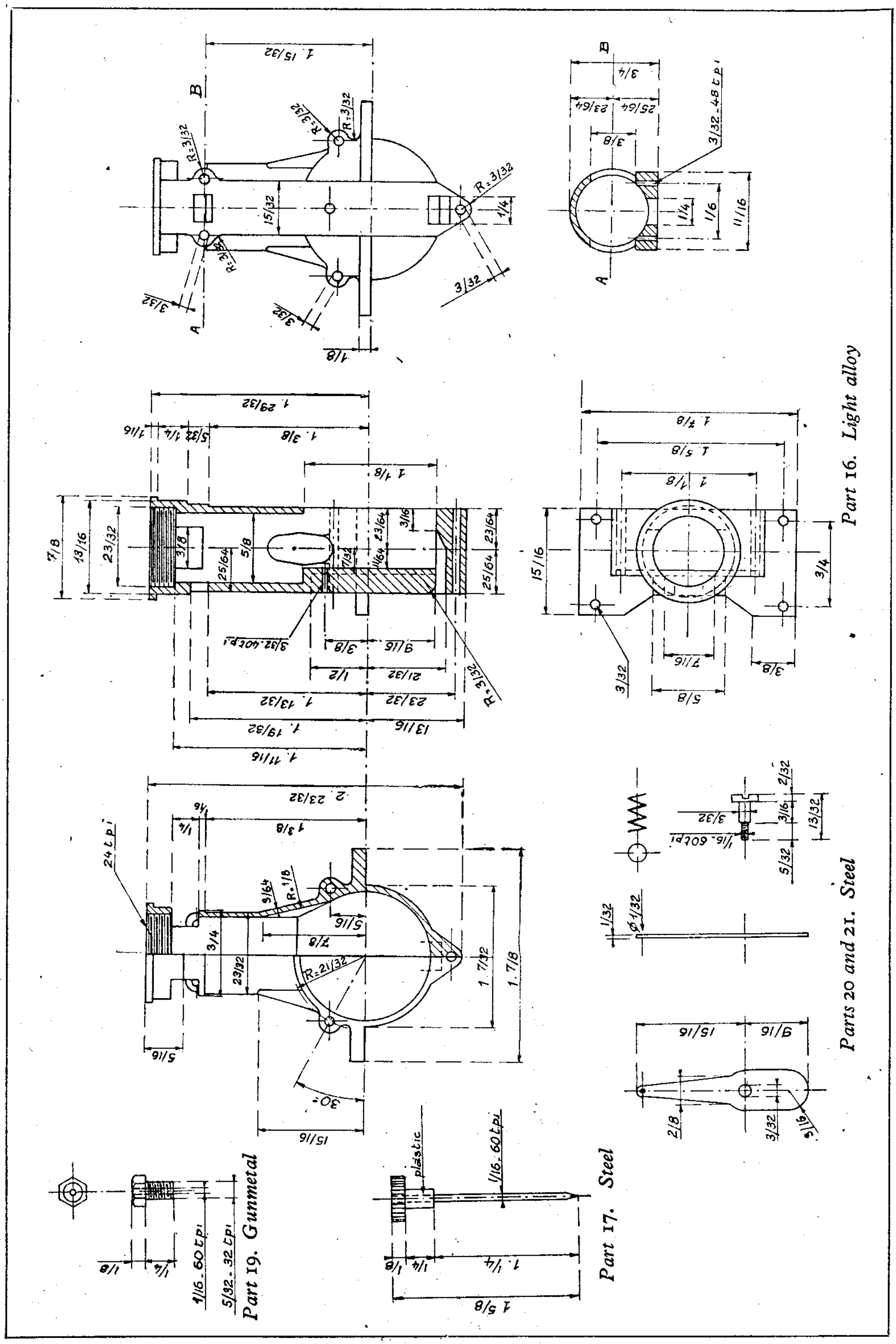


Part 15. *Light alloy*

holes). In the design, the crankshaft runs directly on the crankcase alloy, but if one has no confidence in this, a bronze bushing can be inserted, which will be threaded at the external end to receive the fixing nut (13). The shell (12) is spun in thin aluminium; if one is not accustomed to this peculiar work, it is possible to have it ready made by a specialist. Here again, there is a little difficulty in making the two washers ensuring the tightness of the whole tank, but the best material for it seems to me to be thin vulcanised fibre, thin cork, or strong paper coated with fish-glue. The assemblage of the piece (10) with the main body (16) needs no both threads have to be carefully made, and finely polished to prevent any jamming in the aluminium castings. This method of fixing is very efficient, and one obtains the right position by inserting washers of different thicknesses. The counter-piston is made from three pieces, the counter-piston itself, the finned head and the finned nut. The finned head is shrunk on to the counter-piston after having placed the finned nut.

As the aluminium alloy suffers from a very considerable expansion caused by the heat, it would be impossible to ensure a correct tightness when cold. Because of this, the counter-piston may be made in two ways, first, as indicated on the separate part design, by shrinking on a ring of cast-iron, or secondly, as shown on the elevation design, by casting the aluminium part into a

*Continued from page 544, "M.E.," November 18, 1948.



Part 16. Light alloy

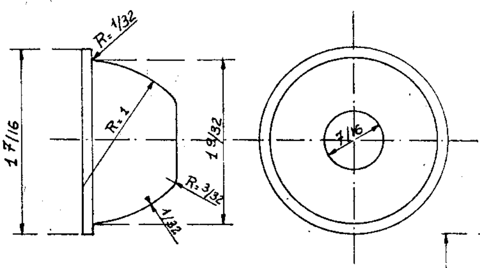
Parts 20 and 21. Steel

Part 17. Steel

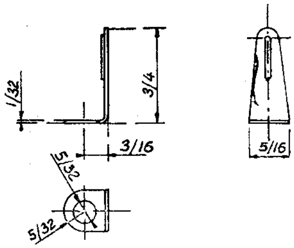
Part 19. Gunmetal

cast-iron ring fitted with an internal groove to keep the aluminium in place. The working piston in cast-iron is very easy to make, the only point requiring particular care being the adjustment in the cylinder to ensure a good compression. It may be noticed that this piston is 23/32 in. in height, while the stroke of the engine is of ¾ in.; there is no mistake about these measures, for this engine has been designed so that the piston in top dead point position uncovers the exhaust port which acts as a complementary inlet port. The connecting-rod, in dural (provided it is of very good quality) needs no bronze bushing. The wrist pin is of hard bronze; although this is an unusual material, it works very well and its diameter is sufficient to prevent it working into the transfer port. The crankshaft must be made from the solid, in a good hard steel, well machined to obtain a good finish.

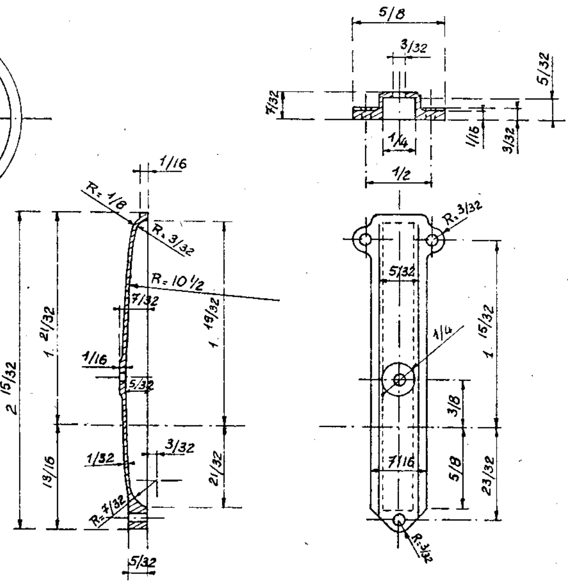
The best way to detect any faults in fitting is to thoroughly clean all the different working parts and assemble them absolutely dry. In order to feel any defects there might be, move them very slowly (in order to prevent jamming). This procedure is far better when the parts are dry, because oil prevents one feeling any small irregularity in the fit. The smallest defect being thus revealed and corrected, one can obtain some kind of perfection. At this stage, the parts can be removed and re-oiled and the whole engine assembled ready for running.



Part 12. *Aluminium*



Part 18. *Steel*



Part 11. *Light alloy*

As for fuels, I suggest a very simple formula such as:

Ether	33	per cent.
Paraffin	33	„ „
Medical Paraffin Oil ..	33	„ „

This engine is capable of producing racing performance, and is suitable for use in the smaller classes of model aircraft and cars.

For the Bookshelf

How and Why It Works. (London: Odhams Press Limited.) 320 pages, size 5¾ in. by 7¾ in. Price 9s. 6d. net.

Science and technology largely govern our lives, individually and collectively, in most things which we use, see or hear about every day. This book is a compendium of concise, illustrated descriptions of many things to be found in the home, office, industry and transport; more than a hundred different subjects are dealt with, all in non-technical language and covering a very wide variety. There are nearly 200 illustrations in half-tone, line and sectional drawings which have been carefully selected to augment the descriptions in the text. It is a book to be thoroughly recommended.

SLIDE- AND PISTON-VALVES

by "Battiwallah"

HOW many model engineers whose constructive instincts are biased in favour of steam engines find the slide-valve something of a mystery? One may safely answer "A large number." Experienced model engineers will know by accustomed use the dimensions of a valve-gear for a given size of cylinder bore. But not a few of them would be "stumped" if they were asked to fix the dimensions and the timing of a valve-gear from first principles. And there is a large following of the less experienced who must, perforce, work to prepared designs. These are quite pardonable shortcomings, for, simple as a slide-valve looks, its theory is by no means so simple. This does not necessarily mean that the theory is beyond the understanding of the average model engineer. Far from it. Not the least of his trouble is knowing where to seek guidance. These notes are an endeavour to provide some elementary guidance in simple terms. Many years ago, when reciprocating steam engines were pre-eminent in the field of prime movers, excellent text-books on the slide-valve were available. Except for a few copies which may still linger on in some of the older technical libraries, there is little hope now of being able to refer to any of these books.

However, interesting as may be the study of a text-book on the subject, for all the model engineer needs it is rather like using a sledge-hammer to crack a nut. Quite a simple and satisfactory solution of a valve problem can be obtained by an easy geometrical construction within limits accurate enough for small engines. Admittedly, the method is not rigorous; but provided the eccentric-rod is two-and-a-half times the eccentric stroke, the error will be less than 2 per cent. As in practice the eccentric-rod is usually greater than five times the eccentric stroke, when the error is less than 1 per cent., it can safely be said that the errors in the method are negligible. An error of 1 per cent. means an actual error *only at the centre of the stroke* of 0.005 in. in a stroke of ½ in. One would not expect to get an overall accuracy much closer than this in small valve-gear. Indeed, in the instances where the author has worked to the dimensions obtained by the method the results have agreed with the predictions as nearly as was measurable by ordinary means.

Like any other computation, the derived data for the valve-gear will depend on certain assumed or given information. This latter is as follows:—

- (*a*) The point of maximum cut-off in the piston stroke is fixed.
- (*b*) The steam port width in the direction of the valve stroke is fixed.
- (*c*) The full opening of the steam port during the admission period is a given proportion of the full port width. A reasonable figure to work to is 75 per cent.
- (*d*) The point of the exhaust opening is fixed with respect to dead top (or bottom) centre of the crankshaft.

In order to convey as clear a meaning as possible in the notes, a few comments on the foregoing points will be helpful.

(*a*) The Cut-off

It is well known that the steam is used most economically if it is allowed to expand during the working stroke. The amount of expansion which is permissible depends on the amount of work which has to be done. For instance, a locomotive hauling a heavy load up a gradient would require steam at the full boiler pressure for most of the working stroke of the piston, and expansive working would be a minimum. On the other hand, were the locomotive coasting down a gradient with a moderate load, the work-effort would be relatively small and, therefore, the admission of steam to the cylinders at full pressure could be cut off early in the stroke and the steam allowed to do a maximum amount of work by expanding in the cylinders.

These considerations apply just as much in a 2½-in. or a 3½-in. gauge locomotive, or any other small scale, as in full-size practice. No to take the full advantage of the expansive working of the steam is simply to waste fuel.

Of course, the valve eccentric gear looks after the variation of the point of steam cut-off in the piston stroke. But we are not concerned with the variation of the cut-off point. All we are concerned with is the maximum or the latest cut-off point. This is usually 75-80 per cent. For model work the lower figure is very convenient. And how is it determined? Very easily, as we shall see. In the diagram, Fig. 1, s represents the main crank revolving about O, and l is the length of the connecting-rod to the same scale as s. Make OA equal to the combined lengths of l and s and mark off AB equal to the length of the piston stroke. Make AC 75 per cent. or ¾ of AB and, with O as centre, strike off an arc of radius s, and from C an arc of radius l. The arcs intersect at D. Join OD and drop a perpendicular DP on OA. The angle DOC is the angle the crankshaft has turned from dead top centre when steam is cut off. At 75 per cent., this angle will be found to be very nearly 120 deg. provided l is 5 or more times s; this is almost invariably so. The angle for 75 per cent. cut-off can therefore be taken as 120 deg., for the error is negligible. The distance PO is practically the same as the distance of C from O^1, which is the mid-stroke position of C, when, very nearly, OD is at 90 deg. to OA. This principle is, in fact, the basis of the geometrical working which will be employed. If any other percentage cut-off is required, CA can be marked off accordingly; for instance, if 80 per cent. cut-off were required, CA would be 8/10 of AB. The angle DOC would then be 127 deg.

A glance at the diagram in Fig. 1 shows that

little is to be gained in making the cut-off any later than 80 per cent. at the very most. For the angle between the crank and the connecting-rod becomes so acute that the piston can translate only a small fraction of its energy into torque on the crankshaft ; consequently, steam is wasted. There is another still more important reason for not exceeding the 80 per cent. cut-off. We shall

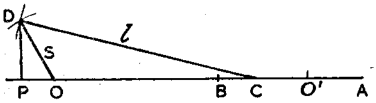


Fig. 1

see later that the ports begin to open to exhaust in the neighbourhood of a crank angle of 160 deg. from d.t.c., and if live steam is admitted to the cylinder up to that angle, there is a good chance of still further waste, for the live steam will blow momentarily straight through the exhaust passages.

(*b*) Steam Port Width

This dimension is the "datum-line" in the working-out of the valve-gear dimensions. So far as model engineering is concerned, it can be assumed, not too liberally nor too sparingly. For on the one hand, more steam than the cylinder could economically dispose of would be admitted, while on the other, restricted steam passage would cause a loss of pressure-" wire-drawing," as it is called. Reasonable working widths are as follows :

Cylinder bore		Steam port width
$\frac{3}{8}$-$\frac{1}{2}$ in.	..	$\frac{1}{16}$ in.
$\frac{1}{2}$-$\frac{3}{4}$ in.	..	3/32 in.
$\frac{3}{4}$-1 in.	..	$\frac{1}{8}$ in.
1-1$\frac{1}{4}$ in.	..	5/32 in.

The port lengths can be taken as 4-5 times the widths.

(*c*) The Port Opening for Steam Admission

It is neither necessary nor desirable that the port should open fully on the steam admission period. The valve stroke would be unduly long, for one thing. The full opening is, however, required in the exhaust period because a greater volume of steam at a lower pressure has to be disposed of. In fact, it will be seen that the port is fully open for an appreciable part of that period so that the spent steam has as unrestricted a getaway as possible. If, during the steam admission period, the port is opened a maximum of 75 per cent. or $\frac{3}{4}$ of its width when the gear is set at maximum cut-off, a reasonable stroke and a good valve timing is obtained.

(*d*) The Point of Exhaust Opening

A close study of the slide valve will show that the later in the stroke the port opens to exhaust, the earlier it will close. And the port may not be opened long enough to discharge the cylinder fully. There is also a period of compression which follows the closing of the port to exhaust so that an early closing will result in too much compression and, therefore, a loss of energy. When the reader has become familiar with Fig. 2, he will further realise that there is a limit to the earliness of the exhaust opening. At 75 per cent. cut-off, if the exhaust opens before the crank is 150 deg. from d.t.c., then in a double-acting cylinder, both ports are opened to exhaust together, one at the beginning of the exhaust period and the other at the close of it. This, of course, is an undesirable state of affairs. We must therefore compromise in not opening the exhaust before 150 deg. nor too late, because we do not wish to waste energy in unnecessary compression. Thus a reasonable figure is 155 deg. If the ports open to exhaust when the crank is at this angle in the direction of the engine's rotation from top and bottom d.c.'s, then we just avoid having both ports open to exhaust at the same time, and also too much compression.

We now begin to see a pattern in the cycle of events. If we assume that steam is admitted to the cylinder at the instant the piston is at either the top or the bottom of its stroke, we have a reference point for timing. We shall, in fact, work to steam admission beginning just at d.t.c. From this instant, then, we have steam at full pressure passing into the cylinder for 120 deg. of the crank's rotation. From thence until the exhaust opens at 155 deg., the steam is doing expansive work. The exhaust period follows and continues for an angular interval of 170 deg. This

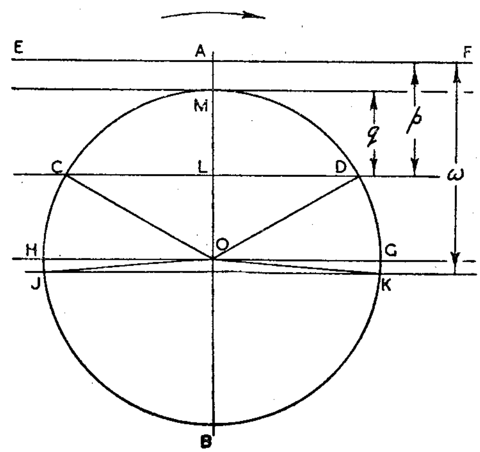


Fig. 2

added to the 155 deg. makes 325 deg., so that the remaining period of the cycle, 35 deg., is the compression period.

And now we have another rather important matter to settle before we can get down to the fixing of the valve dimensions. It is the angle by which the eccentric must lag or lead the crank. For the present we shall consider only a non-reversing engine, for the sake of simplicity.

The Angular Difference between the Piston and Valve Strokes

The angular difference between the arrival at d.t.c. of the piston and the valve depends upon the cut-off, and whether the valve is a D-slide type or a piston type. Whichever type it is, it is not difficult to reason out the lag or the lead for a non-reversing engine, according to the type of the valve.

If it is a D-valve, then it must begin to admit steam just as the piston arrives at d.t.c. As the piston moves on the working stroke, the valve follows in the same direction, for it is increasing the port opening as the piston advances from its starting point. The valve has to travel equal distances in opposite directions to complete the

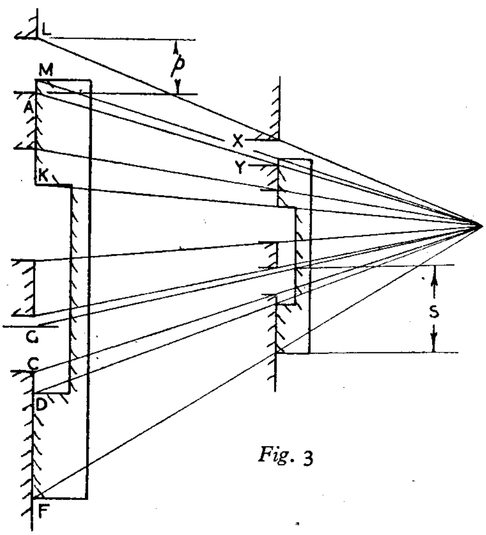


Fig. 3

steam admission period, during which the crankshaft has turned 120 deg., if the cut-off is 75 per cent. Thus the valve moves from the admission commencement point to full steam admission in 60 deg. of crankshaft rotation and at full admission the valve is at one extreme of its stroke. As this extreme of the valve stroke is that in the same direction as the piston stroke, the latter is 120 deg. behind the valve or, in other words, the valve *leads* the piston by 120 deg. The eccentric would therefore have to be fixed so that it would be 120 deg. ahead of the crank in the direction of the crank's rotation.

If a piston valve is considered, then the valve will be at its d.t.c. when the port is fully open to steam admission, which again is when the crank has turned 60 deg. from its d.t.c. In this case, then, the valve *lags* the crankshaft by this angle (60 deg.) and the eccentric must be set accordingly.

To reiterate this data in a condensed form, for a non-reversing engine with 75 per cent. cut-off, a D-slide-valve's eccentric must be set 120 deg. ahead of the crank, and for a piston valve the eccentric must be set 60 deg. behind the crank.

We now have all the necessary preliminary information to enable us to find the valve dimensions and the length of the stroke.

Stroke and Valve Dimensions

The simple geometrical construction is shown in Fig. 2. This is, of course, reduced. Draw a circle about 2 in. radius on a vertical line *AB*. With the same radius strike the arcs *MC* and *MD*. The lines *CO* and *DO* will be at 120 deg. If the crankshaft rotation is clockwise, the point *C* represents d.t.c. of the piston and the point when the valve begins to admit working steam. The valve will be fully open to admission at *M* and it will cut off the steam at *D*. The distance q must be the amount by which the valve opens in the admission period, and *MB* must represent the length of the valve travel. Draw the line *EF* parallel to *CD* so that q is $\frac{3}{4}$ of p, which latter represents the full port width. (We previously fixed full admission at $\frac{3}{4}$ port opening.) We have also previously agreed to have the exhaust opening at 155 deg. from the piston's extreme of stroke. So we set off *OK* at 155 deg. from *OC* or at 5 deg. below *OG*. As the exhaust will close at 5 deg. below *OH*, and *H* and *G* lie on a straight line, the exhaust is open for a total angular period of 170 deg., and clearly the remainder of the stroke, 35 deg., is the compression period. The distance between *EF* and *JK*, w, is the width of one of the valve lands, because the valve has to travel this distance while the piston moves from d.t.c. to the position where the exhaust just opens.

We now have all the essential dimensions on an unknown large scale. Fig. 2 will serve equally for a D-valve and a piston valve. It is a simple matter to scale down p, q, w, and the valve travel *MB*.

D-slide Valve

It is common practice to make the exhaust port twice the width of a steam port and to separate

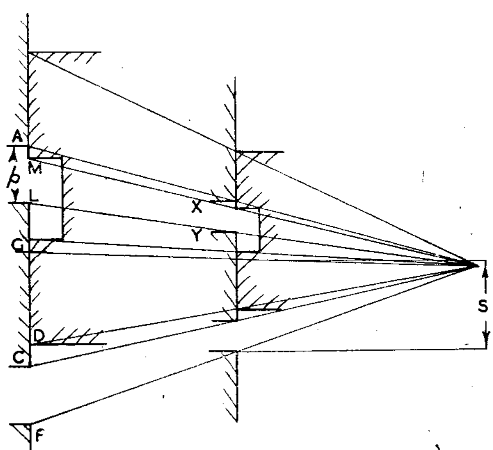


Fig. 4

the steam and the exhaust ports by a distance equal to the steam port width. We will follow this practice and in Fig. 3 set out the ports according to the width p in Fig. 2, but the sizes in this former figure are halved simply to avoid using too much space. There is no need to do this for an actual job. As far as possible, the various points in Fig. 3 have been lettered to agree with the corresponding points in Fig. 2. *LM* is made equal to q and *MK* is w. *LA*, of course, corresponds to p. As the port at the top is at maximum steam admission point, the one at the bottom must be at maximum exhaust opening. To find the distance *CD* in Fig. 3, we must take the difference between *BL* and w in Fig. 2.

DF is also *w*, and there we have the valve set out proportionally. To find the valve stroke to the same proportion, it is easiest to set off *FG* to correspond with *MB* in Fig. 2. To obtain the actual required dimensions, it is best to decide upon a multiple of the actual size so as to be as accurate as possible; five times is a convenient one. Join the various points of the valve in Fig. 3 to any arbitrary point and, parallel to *LF*, draw a line so that *XY* is five times the port width. The five-times figure is completed by selecting the intersections of the line through *XY* and those converging on to the arbitrary point. All that remains is to scale off the required dimensions and divide them by 5. *s* indicates the valve stroke.

Piston Valve

A similar procedure to that for the D-valve is followed in Fig. 4 for piston valves. In this case, however, there will be two separate exhaust ports sited outside the valve travel, and we need only draw the steam ports to find the essential valve dimensions. These ports must be separated by a distance exceeding *w*; a suitable distance is twice the port width, but the finally decided dimension will largely depend upon the features of the cylinder design as a whole. In Fig. 4, *ML* is made equal to *q* as before, and also *DC* is the difference between *BL* and *w*. The same procedure as in Fig. 3 is followed for reducing the dimensions to a known scale.

(*To be continued*)

Editor's Correspondence

Superfine Feed Attachment

DEAR SIR,—According to *Machinery's Handbook*, the ratio of change-gears for cutting

$$\text{diametral pitch worms} = \frac{22 \times \text{t.p.i. on lead screw}}{7 \times \text{diametral pitch}}$$

and the table below is an extract from the one given in the *Handbook* for those pitches and lead screws most likely to be found in use among amateurs.

Diametral pitch	Width of tool	Threads per inch on lead screw			
		4	6	8	10
14	0.069	$\frac{44}{49}$	$\frac{66}{49}$	$\frac{88}{49}$	$\frac{110}{49}$
16	0.061	$\frac{22}{28}$	$\frac{33}{28}$	$\frac{11}{7}$	$\frac{55}{28}$
18	0.054	$\frac{44}{63}$	$\frac{22}{21}$	$\frac{88}{63}$	$\frac{110}{63}$
20	0.049	$\frac{22}{35}$	$\frac{33}{35}$	$\frac{44}{35}$	$\frac{11}{7}$

I have myself just cut a worm on $1\frac{1}{8}$ in. diameter to mesh with 16 P wheels of my lathe, and I found that the width of tool point as given in the *Handbook* proved too narrow to permit proper meshing between worm and wheel. However, having mounted the tool in the top or tool-slide holder, it was a simple matter to feed the tool on 0.020 or so, which apparently gave perfect meshing.

Perhaps your recent correspondent, Major Janes, would kindly let us know how *Machinery's* ratios stand as regards limits of accuracy.

Yours faithfully,

Croydon. L. A. WATSON.

A Traction Engine Hint

DEAR SIR,—A useful collection of traction engines and steam rollers is generally to be found in the yard of Messrs. Bomford & Evershed Ltd., adjoining Salford Priors Station, on the L.M. line between Broom Junction and Evesham. No doubt the firm would readily afford facilities for "measuring up" to any readers interested.

Yours faithfully,

Birmingham. D. B. VERNE.

Rectangular Connecting-rods

DEAR SIR,—*Re* your notes in "Smoke Rings" concerning the cover picture of Mr. Hall's traction engine, and its square connecting-rod, one of these engines can be seen now at Station Hill, Whitchurch, Hants. She is a nine-tonner Burrell, No. 1003, single-cylinder, owned by J. Ward, of Egham, Surrey, and has been "standing idle" for some time now.

Her connecting-rod is perfectly rectangular, and owing to being unable to obtain 166 films, our Mr. Marder, who has furnished me with the details, has been unable to supplement this letter with a photograph.

Yours faithfully,

Andover. R. PEMBLE.

Locomotive Tyres

DEAR SIR,—Your contributor, R. W. Dunn, in his article "Bouquets and Brickbats" certainly drops a brick himself when he states that "It is well known in full-size practice, the tyre itself . . . is pressed on hydraulically on to the steel wheel, thus constituting two entirely separate parts."

May I, as one trained and apprenticed in full-size locomotive building and design, point out that:—

(a) Tyres are invariably shrunk on to wheel centres and not pressed on; it is the complete assembly of tyre and wheel centre which is pressed on to the axle.

(b) All wheel centres are not made of steel; some are of cast-iron, particularly for locomotives used on industrial sites.

(c) Some locomotive wheels are not fitted with tyres, particularly certain contractors' locomotives when built for minimum cost.

Yours faithfully,

Leeds. R. L. ASTON.